climate change initiative

→ WATER VAPOUR

The ESA WV_cci Phase 2

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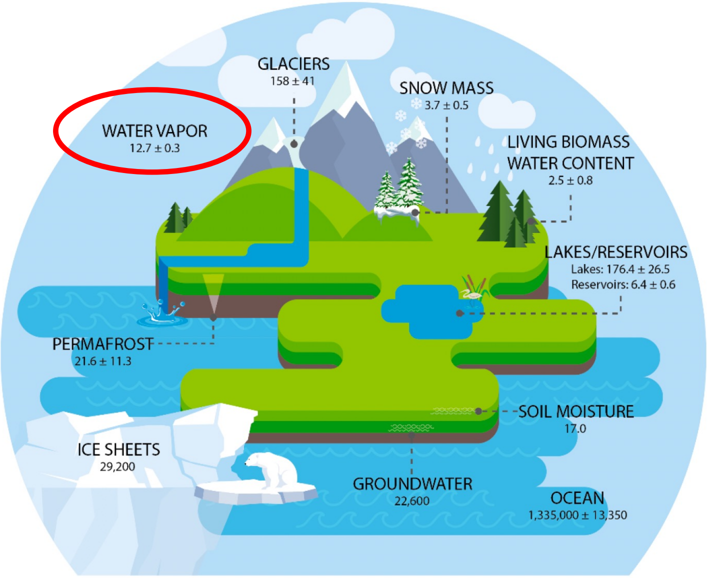
and the WV_cci consortium

water vapour cci

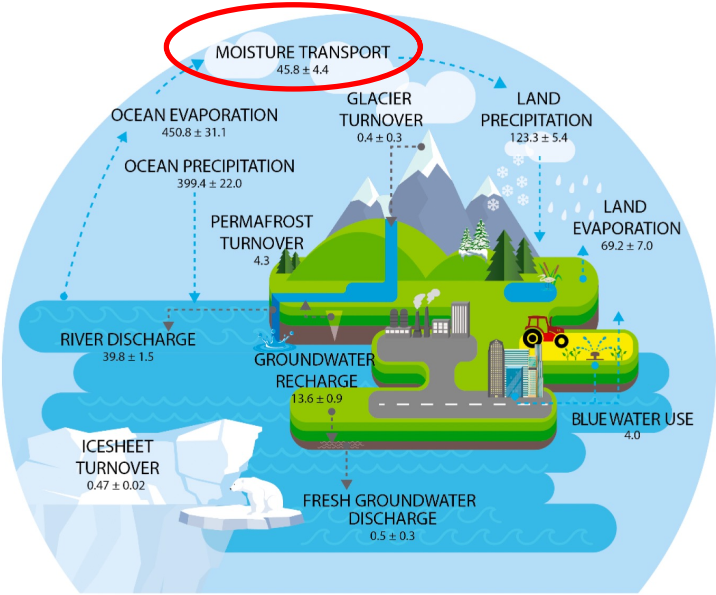
The global water cycle

Dorigo et al. BAMS 2021

- While the global atmosphere contains only little WV compared to other reservoirs, it is crucially important for the 'up-hill' moisture transport!



GLOBAL WATER STORAGES



GLOBAL WATER CYCLE FLUXES

WV – key mediator of the Earth's water cycle

Changes in moisture transport are responsible for many severe CC impacts

- Essential for development of clouds, precipitation, and extreme weather (flooding).
- Impacts surface fluxes (evaporation and condensation) and soil moisture (drought).
- Humidity also affects human health (severity of heatwaves).


© images from pixabay

WV – key mediator of the Earth's energy cycle

- Most important natural greenhouse gas (also in the lower stratosphere).
- Strong positive feedback to anthropogenic climate forcing from CO_2.
  - Influences Earth's radiative balance directly and indirectly (via clouds).

IPCC AR6 – Chapter 2 conclusions

Total column water vapour:

*"Positive trends in global TCWV are **very likely** since 1979 when globally representative direct observations began, although uncertainties associated with changes in the observing system imply **medium confidence** in the estimation of the trend magnitudes."*

"Low confidence in longer-term trends arises from uncertainties in the SST-TCWV relationship and current centennial scale reanalyses, particularly during the first half of the 20th century."

Stratosphere:

*"Due to the discrepancies in satellite and in-situ records, there is **low confidence** in estimates of stratospheric water vapour changes."*

"Recent studies of dynamical influences on SWV have highlighted their substantial roles in driving large interannual variability that complicates trend detection."

"Disregarding dynamic influences on SWV, an ERF of 0.05 ± 0.05 W m−2 is estimated for SWV produced by CH_4-oxidation, unchanged from AR5."

WV_cci Phase 1: Results & Achievements

- Updated **water vapour user requirements** based on climate community feedback

  → WV_cci User Survey (2018) & User Workshop (2021)
- **Developed new algorithms** for both retrievals and merging
- Improved **uncertainty characterisation**
- Extended **validation of input and merged datasets** against various reference datasets (CCMs, GCMs, NWP models, insitu & remote observations)
- Delivered **four Climate Data Records**:
  - CCI TCWV-land (see **ESA ODP!**) & CM SAF/CCI TCWV-global (COMBI)
  - CCI WV-strato & CCI WV-UTLS
- Produced comprehensive documentation
- Carried out **three user case studies** (CMIP6-comparison by He et al.; SWOOSH-comparison by Hubert et al.; ERA5-comparison on atmospheric rivers by Barca-Eiras et al.)

  → **Website: https://climate.esa.int/en/projects/water-vapour/**

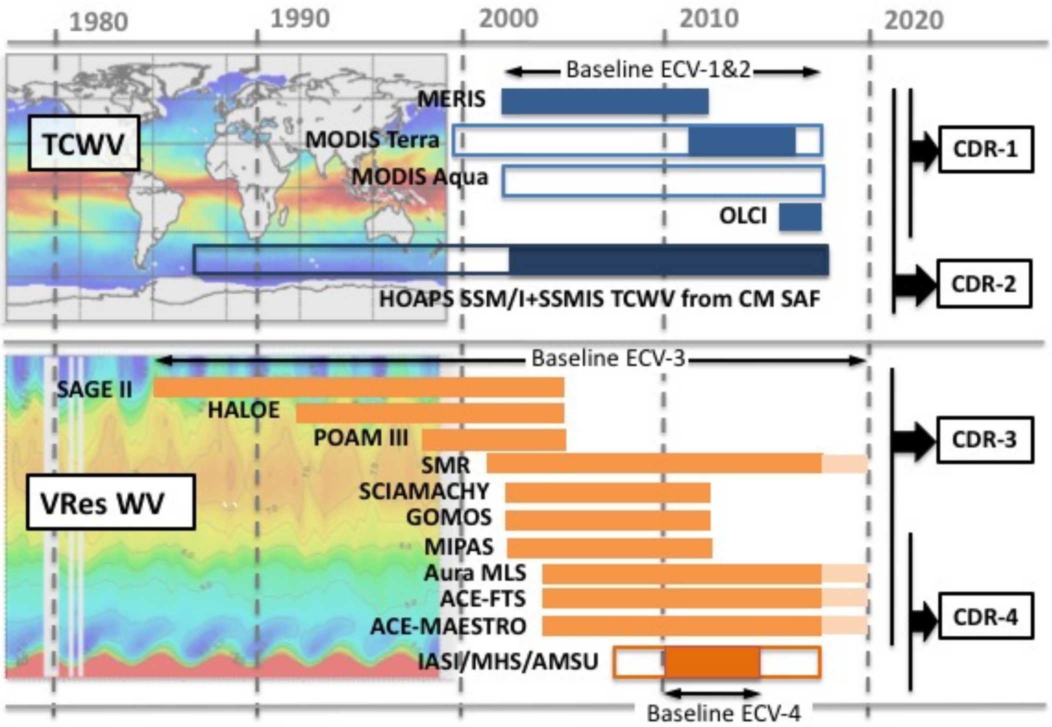
Available WV_cci CDRs

Total Column (TCWV) Products

- **2002-2017**
- Land (clear-sky)
- Ocean (all-sky)
- L2 & L3 (daily & monthly gridded)
- **0.5 and 0.05** degree resolution

Vertically Resolved (Profile) Products

- **1985-2019** and **2010-2014** for stratosphere (2D) and UTLS (3D)
- L2 & L3 (monthly gridded)
- Horizontal resolution: **5 deg**
- Vertical resolution: **~2-5 km**



Availability

CCI TCWV-land
Open Data Portal

CM SAF/CCI TCWV-global
Coming very soon!

CCI WV-strato
Coming very soon!

CCI WV-UTLS
Prototype version, delivery upon request

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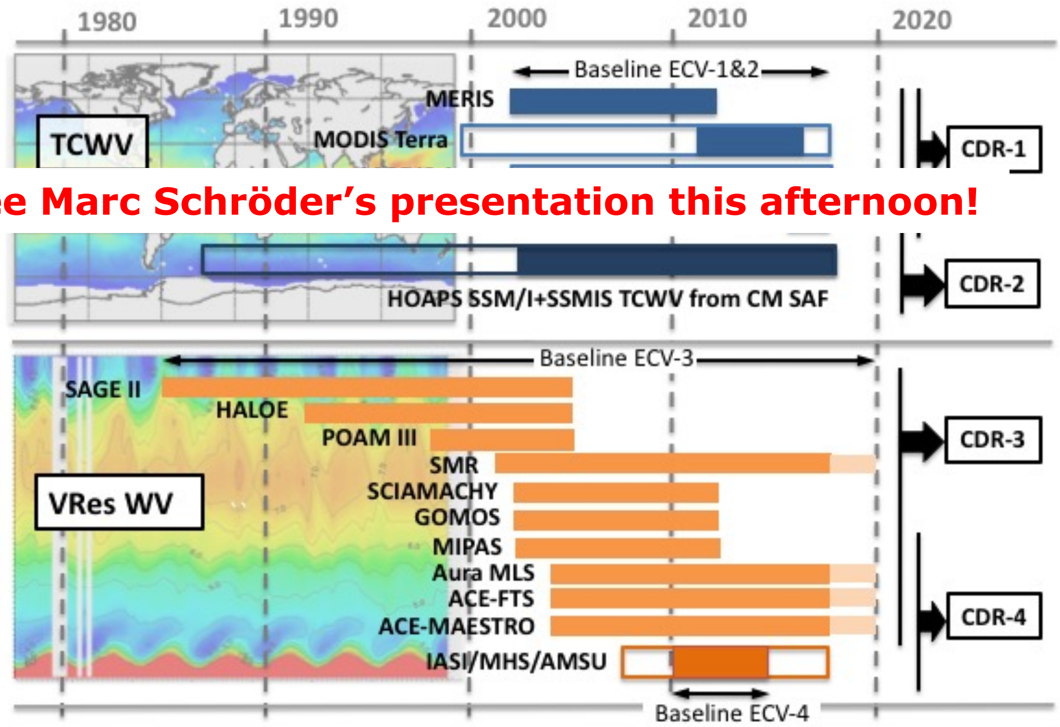

See Marc Schröder's presentation this afternoon!

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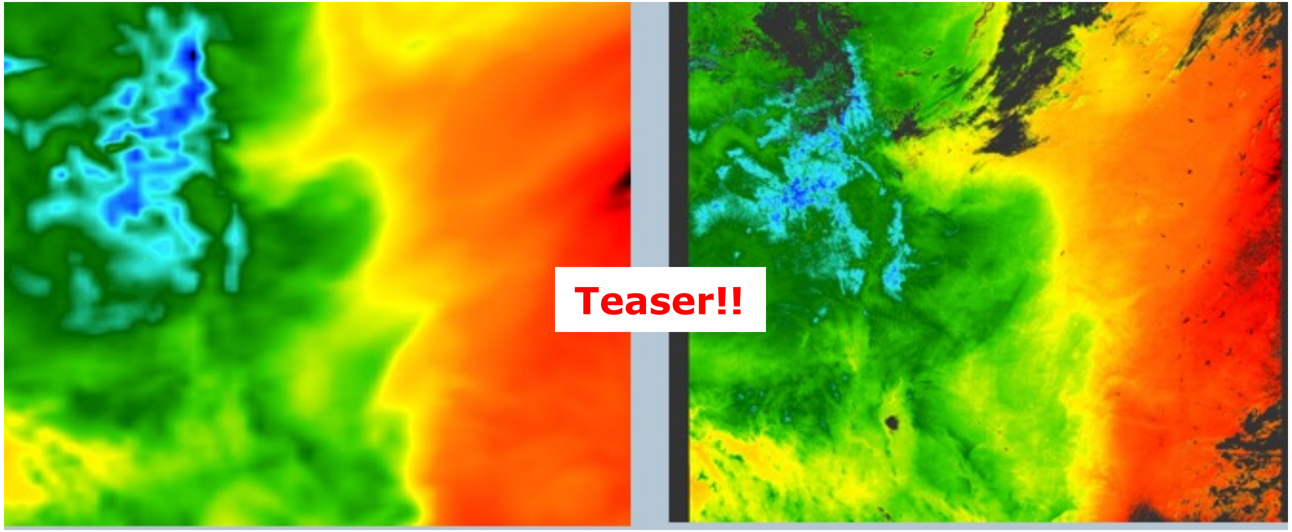
CCI TCWV-land example

High spatial resolution products reveal great detail in water vapour distributions than reanalysis.

The observations (OLCI, right) reveal greater detail than ERA-Interim (left)

(5 km versus 25 km resolution)

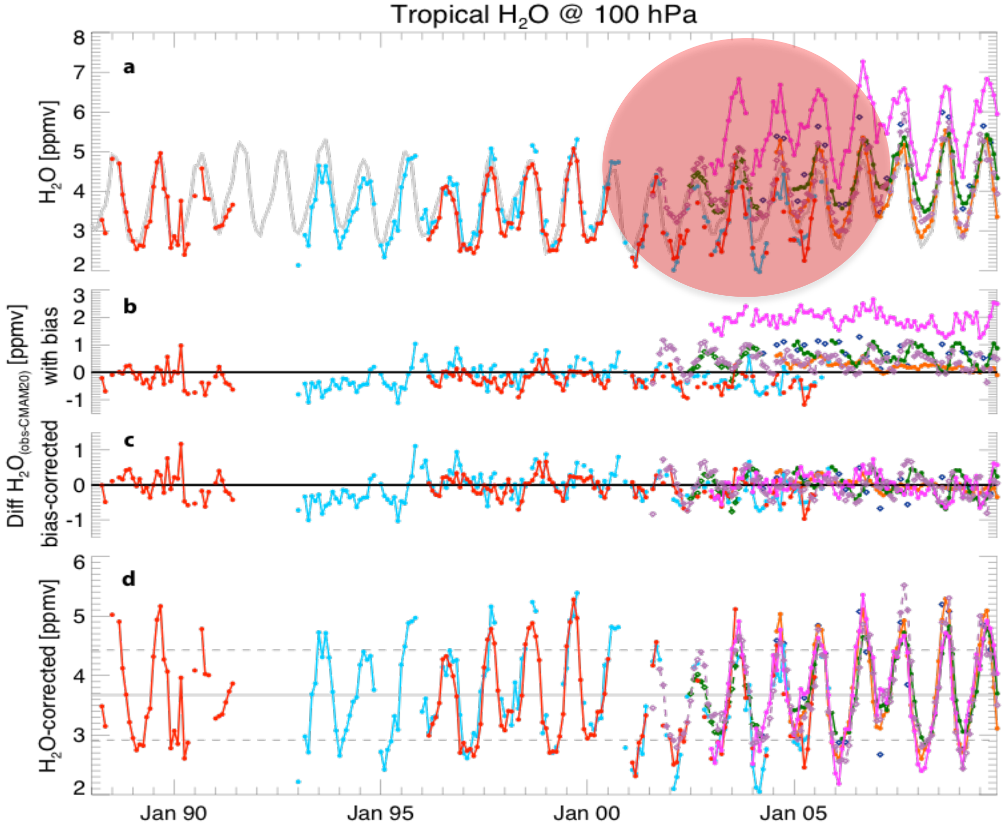


Courtesy Rene Preusker & Jürgen Fischer

Merging method CCI WV-strato (CDR-3)

Hegglin et al., *Nature Geosci. 2014*

- Large biases prevent straightforward merging.
- Using a chemistry-climate model as transfer function.
- Result is homogenized time series of stratospheric water vapour, which can be merged.

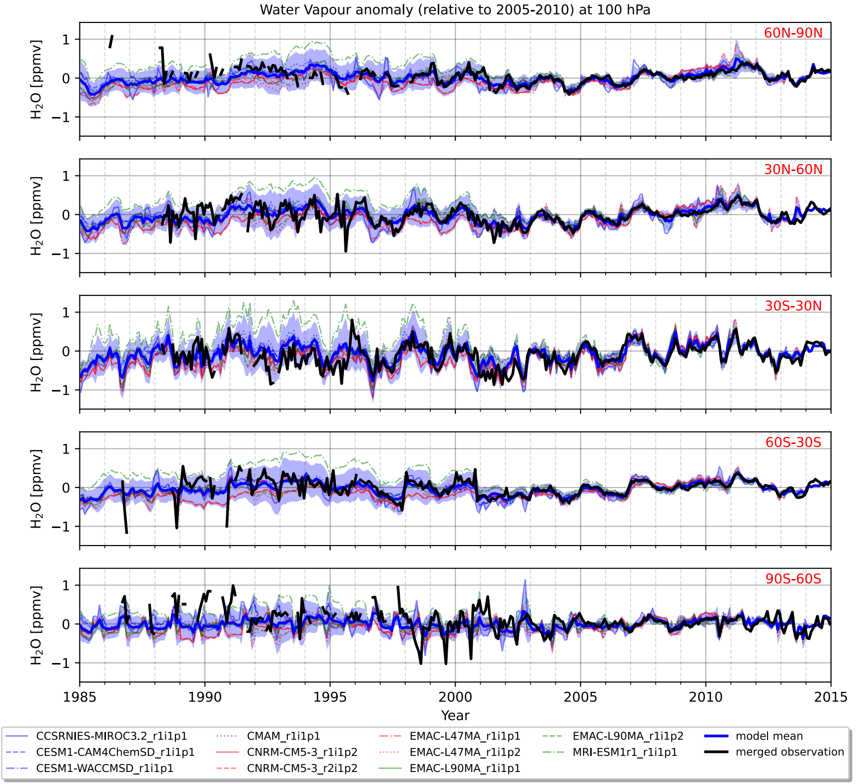


CCI WV-strato versus CCMs

Hegglin et al., in preparation

esa

- Water vapour anomalies removing the seasonal cycle during 2005-2010 from CDR-3 and CCMI are shown in different latitude bands.
- The good agreement between simulations and merged data indicates the CDR-3 dataset has very high quality in the LS.
- The quality of CDR-3 dataset increases in the later years with more accurate satellite observations merged.



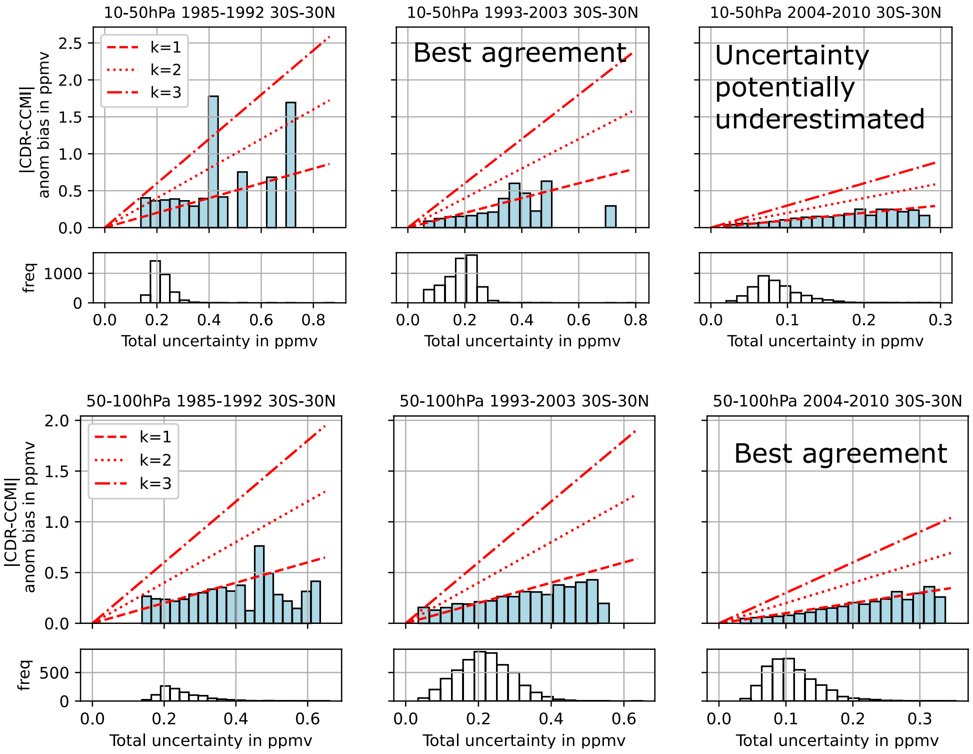
CCI WV-strato uncertainties

Hegglin et al., in preparation

- CDR-3 uncertainties have been evaluated against CCMI model data following Immler et al. (2011):

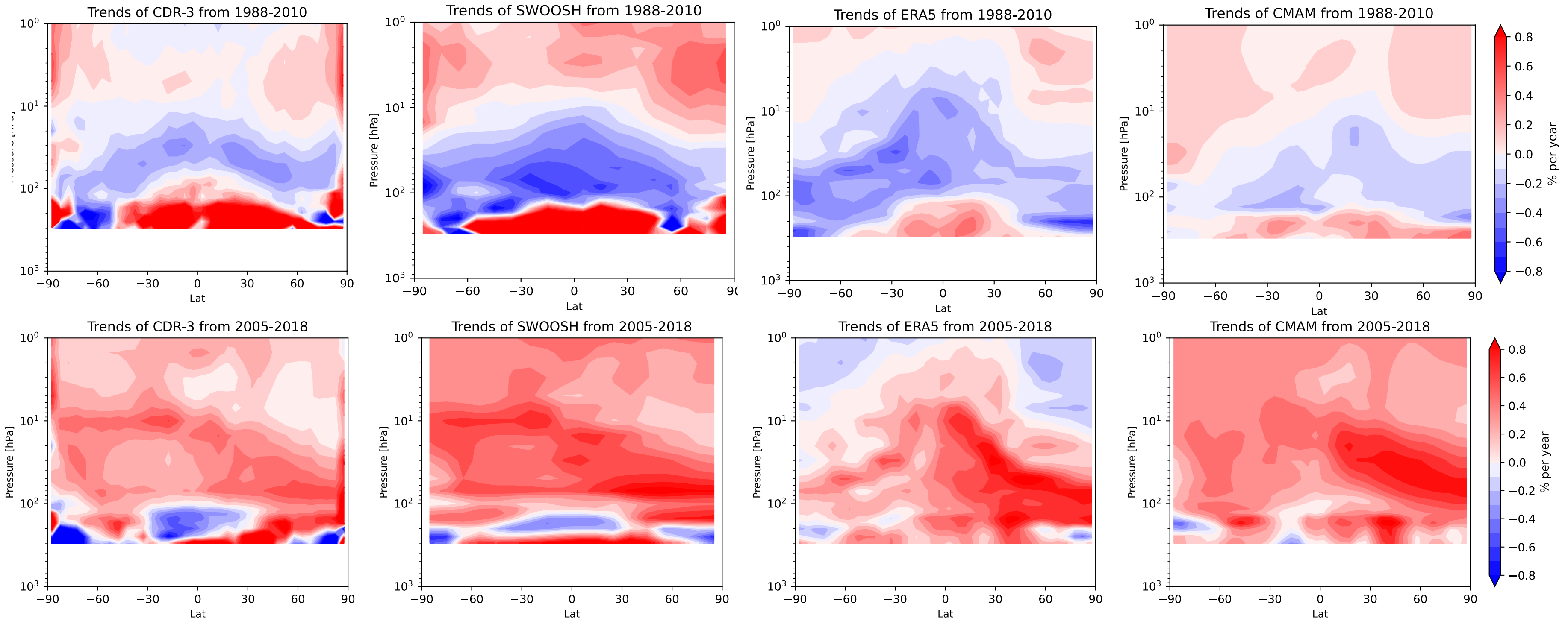
$$|x_i - y_i| < k\sqrt{\sigma^2 + u_{x_i}^2 + u_{y_i}^2}$$

- The uncertainty in the models (u_{yi}) is based on the standard deviation over the CCMI models.
- The anomaly biases decrease slightly over the three periods considered, while the total uncertainty decreased significantly.
- Uncertainties distributions not Gaussian!



Stratospheric WV trends

Ye et al., in preparation



See also Daan Hubert's presentation!

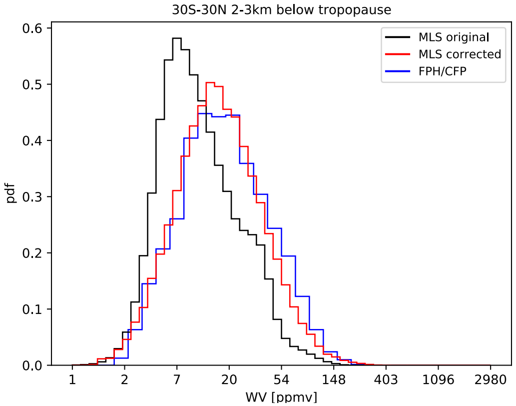
Merging method CCI WV-UTLS (CDR-4)

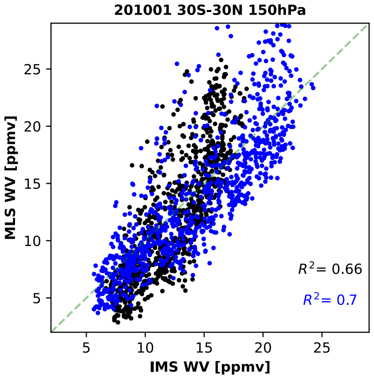
Ye et al., in preparation

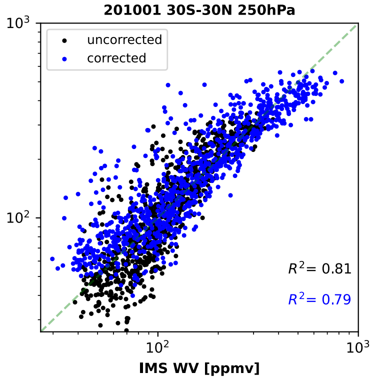
- **A "climatological" distribution** of balloon-borne hygrometer profiles in tropopause coordinates is used as a reference for bias-correction.
  1) 3-monthly FPH/CFH profiles over the full period (2000-2017)
  2) Divide globe into 5 latitude bands (every 30° except for tropics)
  3) 1 km altitude bins in tropopause coordinates

- **Quantile-mapping technique** is used to apply biases to L2 satellite profiles, not a constant offset

- Bias-correction is performed only in UTLS: 300-100 hPa
  1) MLS and MIPAS WV for 100−10 hPa
  2) RAL IMS WV for 1000−300 hPa

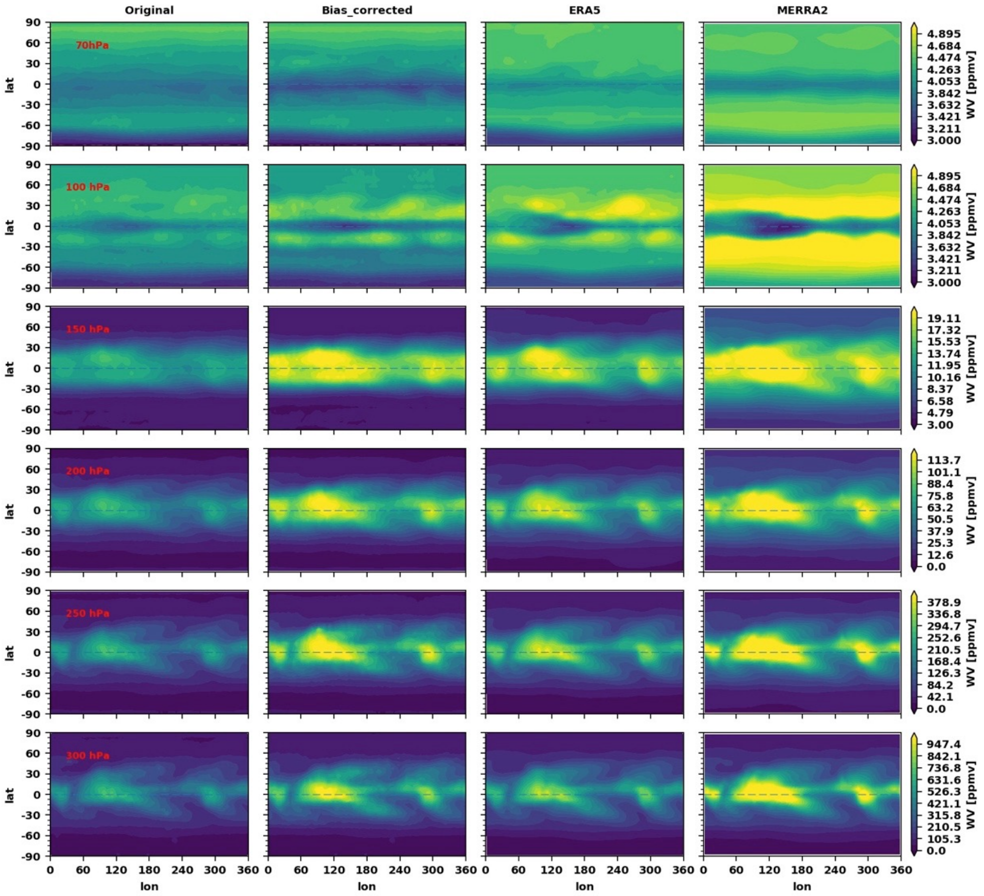






CDR-4 vs reanalysis datasets

Ye et al., in preparation



Comparison against reanalyses

- Bias correction keeps the horizontal distribution pattern
- Bias correction method largely increases water vapour in the upper troposphere
- Problems persist to resolve reasonable seasonality, with too high values during summer.

Conclusions and Outlook

- **WV_cci Phase 1 ends soon, WV_cci Phase 2 starts up right after! June?!**
- **Focus of WV_cci Phase 2:**
  - Extend datasets into the past and the present (CDR-1 to CDR-4)
  - Improve merging algorithms further (CDR-1 to CDR-4)
  - Produce regional, higher-resolution CDR examples (CDR-1)
  - Capitalise on CDRs through exciting new user case studies!
- **Potential users interested in using our data, please watch the space:**

https://climate.esa.int/en/projects/water-vapour/

and/or contact us via email **m.i.hegglin@reading.ac.uk**

List of WV_cci publications

WV_cci project papers:

- Preusker et al., Retrieval of daytime total column water vapour from OLCI measurements over land surfaces; Remote Sensing, 13, 932, https://doi.org/10.3390/rs13050932, 2021.
- Eiras-Barca et al., Analysis of the main sources associated with moisture transport events with the new ESA CCI CDR v2 Water Vapour Initiative Data, *QJRMS*. (in revision)
- He et al., CMIP6 analysis, *Atmos. Chem. Phys. Discuss.* (in revision)
- Trent et al., Overview and evaluation of RAL IMS tropospheric water vapour and temperature profiles from IASI, GMD, to be submitted.

WV_cci related papers:

- Popp et al., Consistency of satellite climate data records for Earth system monitoring. *Bull. Amer. Meteor. Soc.,* doi: https://doi.org/10.1175/BAMS-D-19-0127.1, 2020.
- Fadnavis et al., A rising trend of double tropopauses over South Asia in a warming environment: Implications for moistening of the lower stratosphere. *Int. J. Climatol*., 1–16, DOI: 10.1002/joc.6677, 2020.
- Dorigo et al., Consistent monitoring of global water cycle variability across scales: Where do we stand?, BAMS, https://doi.org/10.1175/BAMSD-19-0316.1, 2021.
- Hegglin, M. I., et al., Overview and update of the SPARC Data Initiative: comparison of stratospheric composition measurements from satellite limb sounders, Earth Syst. Sci. Data, 13, 1855–1903, https://doi.org/10.5194/essd-13-1855-2021, 2021.